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Reply to Attn of: **CCL**

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FROM: C/Assistant Administrator for Commercial Programs

SUBJECT: Electronic Still Camera Project on STS-48

The Electronic Still Camera (ESC) project, scheduled to fly as a part of the STS-48 mission in September 1991, is sponsored in part by the Office of Commercial Programs (OCP), with hardware development and support provided by Johnson Space Center (JSC), Autometric, Inc. (Autometric) and 3M Corporation (3M).

The Shuttle crew will operate the ESC (developed in part by JSC), which is a hand held camera that electronically captures and produces digital images with resolution nearing film quality. The ESC will be operated in conjunction with a 3M-developed Color Laser Imager (CLI) located in the JSC ESC Lab and operated by Autometric. The CLI will produce hard-copy prints of ESC images taken by the crew during the mission. The entire process of capturing an image in orbit to producing a hard-copy print at JSC should take about one hour.

The objectives of the ESC mission are to test and assess the effectiveness of the ESC during on-orbit operations; to verify the downlink interface; and to test on-orbit image processing capability. It is estimated that it will take three flight opportunities to satisfy these objectives, which will be accomplished in order of system availability.

The enclosed report contains a brief description of the ESC activities on STS-48. Please note this report is not part of the regular Mission Operation Report (MOR) series. It is a special report designed to inform the OCP community about details of a commercial development flight activity.



James T. Rose

ELECTRONIC STILL CAMERA PROJECT

**Sponsored In Part By:
The Office of Commercial Programs**

Hardware Development And Support Provided By:

**Johnson Space Center
Autometric, Inc.
3M Corporation**

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GENERAL

On behalf of NASA, the Office of Commercial Programs (OCP) has signed a Technical Exchange Agreement (TEA) with Autometric, Inc. (Autometric) of Alexandria, Virginia. The purpose of this agreement is to evaluate and analyze a high-resolution Electronic Still Camera (ESC) for potential commercial applications. During the mission, Autometric will provide unique photo analysis and hard-copy production. Once the mission is complete, Autometric will furnish NASA with an analysis of the ESC's capabilities.

Electronic still photography is a developing technology providing the means by which a hand held camera electronically captures and produces a digital image with resolution approaching film quality. The digital image, stored on removable hard disks or small optical disks, can be converted to a format suitable for downlink transmission, or it can be enhanced using image processing software. The on-orbit ability to enhance or annotate high-resolution images and then downlink these images in real-time will greatly improve Space Shuttle and Space Station capabilities in Earth observations and on-board photo documentation.

The key hardware element in this system is the high-resolution ESC, of which several commercial and government models exist. By placing a Charge Coupled Device (CCD) at the film plane, the ESC is converted from a professional quality film camera to a digital image storing device. In addition to comprising zoom and wide-angle lenses and a flash, the ESC can add removable filters and image intensifiers that provide low-light capability and modest spectral capability. Space applications of electronic still photography technology will be demonstrated on the Space Shuttle using the ESC, an Orbiter downlink interface, a monitor, and a portable computer to support image processing.

While the Shuttle crew operates the ESC, Autometric will operate a 3M-developed Color Laser Imager (CLI) located in the Johnson Space Center (JSC) ESC Lab. The CLI will facilitate hard-copy production of ESC images downlinked to JSC during the mission. The CLI, is an advanced 300-dpi (dots per inch) color output device capable of printing over 170 photographic images per hour. The entire process, from taking a picture in orbit to getting a black-and-white copy on the ground, should take less than one hour.

The ESC is flying under Detailed Test Objective (DTO)-648, and is co-sponsored by JSC's Man-Systems Division and Astronaut Office. The DTO's objectives are to test and assess the effectiveness of the ESC during on-orbit operations; to verify the downlink interface; and to test on-orbit image processing capability. These objectives will need at least three flight opportunities to be satisfied, and they will be accomplished in order of system availability. The first flight of DTO-648 is on STS-48, September 12-18, 1991. The ESC will also fly on STS-42, currently slated for launch in January 1992. Future flight opportunities under consideration include STS-45 in April 1992, and STS-50 in June 1992.

BACKGROUND

The ESC mission on STS-48 will involve the cooperative efforts of the Flight Equipment Section (FES) of JSC's Man-Systems Division and Autometric. Both the FES and Autometric have extensive knowledge and experience in the area of space camera systems and, as such, are expected to make notable contributions to this mission.

The FES has been in existence since the beginning of the Gemini Space Program (1962), and has primary responsibility for all photographic systems flying on manned space missions. Such photographic systems include a 16mm motion picture camera system; 35mm, 70mm, and 5-in. still camera systems; and the Large Format Camera System which has flown on previous Shuttle missions. Over the years, the FES has become known throughout NASA for its expertise in space qualified camera systems.

The ESC is the latest development effort to come from this group. This effort evolved from a need for a more efficient method of returning high-resolution imagery to the ground during long duration missions. Future development plans for the ESC include upgrading to higher-resolution CCD's, and eventually to a full-color/multi-spectral camera using three high-resolution CCD's.

Autometric has been developing applications for remote sensing data since 1957. Its capabilities include imagery exploitation, collection management, mission planning, and development of integrated software and hardware systems for Geographic Information Systems (GIS), photogrammetry, and data handling. Application specialties include advanced technology in land use management systems, digital cartographic and imagery work stations, and natural resource analysis and exploration.

Autometric has 170 employees operating in seven different locations in the United States. The staff is a unique team of users, engineers, cartographers, systems analysts, GIS specialists, photo interpreters, and database managers. Autometric also maintains the largest research and development staff of expert multi-sensor image analysts in private industry.

Among its previous commercial efforts, Autometric has made radar surveys for oil and petroleum companies, provided orthophoto mapping for the state of Vermont, and provided wetlands mapping for the state of Maryland. Autometric has provided an assessment of commercial applications for the NASA Large Format Camera System, and has studied the development of a GIS-based imagery archive for NASA remote sensing imagery.

OBJECTIVES

The objectives for DTO-648 are:

- test and assess ESC capabilities during on-orbit operations;
- verify downlink interface; and
- test on-orbit image processing capabilities.

Specific aspects relating to these DTO objective are:

- determine the ESC's response to the photographic conditions encountered on-orbit using a variety of lenses and camera setting combinations;
- demonstrate successful downlink from the ESC;
- demonstrate successful on-board image display and downlink from the Playback Downlink Unit; and
- demonstrate on-board image processing and establish the key set of algorithms necessary to support observational science users.

The commercial objective for this activity, as established by the TEA between NASA and Autometric (the commercial partner in this project), is:

- to evaluate the utility of the ESC for commercial applications in areas such as close range photogrammetry, terrestrial monitoring, and near real-time capabilities.

To demonstrate the ESC's real-time capabilities, Autometric has planned three ground-based demonstrations that will take place during the mission and will illustrate the advantages of a digital system for near real-time activities.

The first demonstration will provide hard-copy prints of the downlinked images taken during the mission. Once the images are received by JSC, they will be saved to a disk and transferred to the ESC Lab at JSC. The images will then be processed by Autometric and printed with the 3M-developed CLI.

The second demonstration will be performed in conjunction with the Virginia Institute of Marine Sciences (VIMS) of the College of William and Mary, Williamsburg, Virginia. A simultaneous collection of images of the Colonial National Historic Park and the Middle Peninsula of Virginia will be collected by VIMS from an airborne sensor. This will provide additional imagery to compare with the ESC data for ground truth testing.

OBJECTIVES (continued)

The third demonstration will test the ESC's response to ad hoc imaging requirements which could prove critical to the management of natural disasters and other crises. Once the mission begins, an area of interest will be named, including a precisely-defined location and imagery collection times. The imagery will then be downlinked to JSC and printed.

ESC DESCRIPTION

The ESC is a hand held, self-contained digital camera developed in part by JSC's Man-Systems Division. The ESC was developed primarily for use on long duration missions, but will have many applications on future Shuttle flights. It is expected that this camera will lead to the development of other ESC technology such as higher-resolution monochrome cameras, high-resolution full-color cameras, multi-spectral cameras, and low-light level cameras.

The ESC system has the basic photographic platform of a 35mm Nikon F4 camera; it is battery operated and designed to accept any lenses/optics with a Nikon mount. In order to convert the ESC from a 35mm camera to a digital image storing device, a CCD was placed at the film plane of the Nikon F4. The digital images produced by the ESC are monochrome and are stored on a removable computer hard disk with a 40-image-per-disk storage capacity. Images will be transmitted to JSC via Orbiter digital downlinks. Prior to downlinking, though, the Shuttle crew can view and enhance/process the images on the Orbiter using a modified laptop computer.

The flight hardware for the STS-48 mission includes the ESC, a flash, five different lenses, a CCD to store 200 images, and an on-board microcomputer that has image processing software specifically designed for ESC missions. The flight hardware weighs 35.5 pounds and its volume is equivalent to the size of one middeck locker.

MISSION SEQUENCE AND SUPPORT

The ESC will be stowed in a middeck locker, making the ESC easily accessible to the Shuttle crew. One primary crew member will perform ESC activities, which will require downlinking images for at least 30 minutes per day during periods of communication coverage on a Ku-band downlink. The 30-minute period can either be continuous or broken down into smaller increments of time. Test objectives for the ESC will be accomplished in the order of systems availability.

The following is a list of tests that the crew will conduct to provide data from which the ESC system will be evaluated.

- Out-the-window imaging with various focal length lenses.
- In-cabin imaging with available light and flash, including macrofocus.
- Evaluation of manual and automatic metering techniques.
- Evaluation of hard disk cartridge operations.
- Evaluation of on-board image processing/display capability in conjunction with downlink operations.
- Use of Orbiter downlink interface to provide images from the ESC directly and from hard disk playback.
- Transfer of images to Playback Downlink Unit for annotation and digital image processing evaluation.
- Use of Orbiter downlink interface to provide raw and processed images, plus annotation.

Images collected throughout the mission will be recorded on-board and downlinked to JSC's Payload Operations Control Center (POCC). The images will be processed at the POCC on a Sun Workstation and stored on Bernoulli disks. These disks will be hand carried to the JSC ESC Lab where the images will be placed on an IBM personal computer (PC). A Silicon Graphics Workstation will access the images from the IBM PC using the Ethernet communications network, and then send them to the 3M-developed CLI to be printed. The resulting hard-copy images will include a NASA-Autometric-3M logo and a CCD-issued control number. The JSC Public Affairs Office will select several images during the mission for distribution to the press.

After the mission, JSC will provide Autometric with data collected during the mission. Autometric will provide JSC with a technical assessment of the imagery and an evaluation of the ESC's capabilities.

MISSION MANAGEMENT

During the STS-48 mission, the JSC ESC Lab will staff the Payload Operations Control Center, and the Office of Commercial Programs and Autometric will staff the Customer Support Room. Personnel from Autometric and 3M will be located in the JSC ESC Lab to operate the 3M-developed CLI.

Key people associated with the TEA and involved with the evaluation of potential commercial applications of the ESC include:

**Deputy Assistant Administrator
(Special Projects), Office of
Commercial Programs**

**Mr. J. Michael Smith
NASA Headquarters, Code C**

**Commercial Agreements Manager,
Commercial Development Division**

**Mr. John Emond
NASA Headquarters, Code CC**

ESC Program Manager

**Mr. H. Don Yeates
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Autometric Program Manager

**Ms. Jennifer Visick
Autometric, Inc., Alexandria, Va.**

ACRONYMS

CCD	Charge Coupled Device
CLI	Color Laser Imager
DTO	Detailed Test Objective
ESC	Electronic Still Camera
FES	Flight Equipment Section
GIS	Geographic Information Systems
JSC	Johnson Space Center
NASA	National Aeronautics and Space Administration
OCP	Office of Commercial Programs
POCC	Payload Operations Control Center
TEA	Technical Exchange Agreement